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THREAD-WORM OF PORK (TRICHINA SPIRALIS.)

Publications will be sent to any address in North Carolina upon application.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

INCLUDING

THE FERTILIZER CONTROL STATION

AND THE STATE WEATHER SERVICE,

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RALEIGH, N. C.

THREAD-WORM OF PORK (TRICHINA SPIRALIS.)

There is so much danger to human life from eating pork infected with thread-worms (*Trichina spiralis*) that the public generally should be warned of the fact and become more familiar with the life-history of the worm, and wherein lies the source of danger. This knowledge would enable them to adopt measures not only for preventing its entrance into the human system, but also to prevent its spread in other animals, and so decrease the liability of contagion. To give this information in a condensed form is the object of the present bulletin, written by Dr. F. P. Williamson, Consulting Veterinarian to the Experiment Station. The Station is much indebted to the Bausch & Lamb Optical Co., of Rochester, New York, for the loan of the electrotypes used, which are from an interesting pamphlet, entitled "Trichinæ," by John Phin.

The disease produced by the pork or thread-worm must not be confounded with that produced by the tape-worm (*Tænia solium*), though the manner in which it reaches the human system is almost identical, namely, by eating imperfectly cooked meat infected with the immature forms, or by eating green vegetables which may be affected in the same way. A discussion of the tape-worms, *Tænia solium* and the *Tænia echinococcus*, will be reserved for a future bulletin.

H. B. Battle, *Director.*

TRICHINA SPIRALIS, OR THREAD-WORM.

By F. P. WILLIAMSON, Consulting Veterinarian.

The most common way in which human beings become infested with trichina is, undoubtedly, from eating trichinous pork. John Phin gives three other ways in which animals may become affected, *i. e.*, eating excrementitious matter of animals themselves affected, by drinking water in which the flesh of animals affected has decomposed, by eating vegetables (cabbage, lettuce, celery) manured with excrement or offal of animals affected.

Trichina spiralis (coiled hair), or thread-worm, derives its name from the appearance presented in their encysted form. It is as interesting as any of the animal parasites that inhabit carnivora.

The position they occupy in the classification of worms can be seen from the accompanying diagram (after Minot).

Branch.	*Class.*	*Genera.*
Vermes. (Worms).	I. Plathelminthia.	
	II. Rotifera.	
	III. Gastrotricha.	
	IV. Nematoda	Leptodera (Vinegar Eel.) Rhobditis (Lung Worm of Frog.) Anguillula (Root Worm.) Enoplus (Aquatic Worm.) Filaria (Guinea Worm.) Trichina (Muscle Worm.) Trichocephalus (Bowel Worm.) Eustrongylus (Trachea Worm.) Syngamus (Gape Worm.) Oxyuris (Pin Worm.) Ascaris (Bowel Worm.) Gordius (Hair Worms.)
	V. Acanthocephali.	
	VI. Chætognathi.	
	VII. Nemertea.	
	VIII. Gephyrea.	
	IX. Annelida.	

Others of this group are not so important as trichina spiralis, but are more often found; some of these are trichocephalus dispar (whip-worm), which is found at times in both large and small intestines; oxyuris vermicularis (sharp-tailed worm), which lives in the intestines; eustrongylus gigas (round worm), which is found in the kidneys, rarely elsewhere; dochmius duodenale, which inhabits the small intestines, causing at times violent diarrhœas.

Thread-worms can best be seen in their encysted form, where they lie coiled up in a calcareous mass of their own deposit (see Figures 2 and 3) in the muscles of carnivorous animals. To the naked eye the cysts appear as grains of sand (Figure 1). So long as they remain in this shell they are harmless. But when some other animal eats the flesh of the one in whose muscles the trichinæ are encysted, they are set at liberty in the alimentary canal of the new host, there to produce young and die. The young then burrow through the intes-

tinal walls to become encysted and embedded in muscular tissue as before.

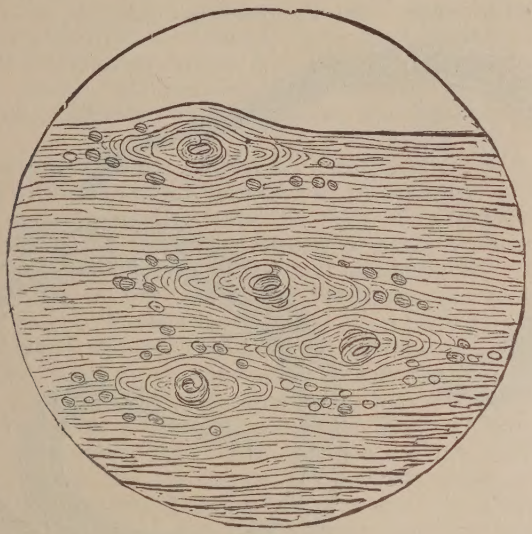

Figure 2.

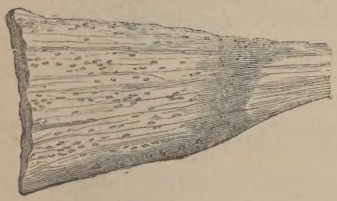

Figure 1.

Figure 3.

TRICHINA SPIRALIS IN FLESH IN THE ENCYSTED FORM.

Figure 1 shows the appearance of these parasites in meat examined with the naked eye. Figure 2 shows a microscopic section, magnified 25 diameters. Figure 3 shows a section of a cyst still more highly magnified.

These are encysted forms in which it is possible to exist 10 or 20 years without damage and without losing power. After the flesh is eaten, the cyst is dissolved and the worm is set free to bore its way through the flesh, multiply and produce the disease known as trichinosis.

Let us follow the course of these micro-organisms more in detail through their life-history.

Take pork in which are some encysted trichinæ. They are then in the larval form about $\frac{1}{28}$ of an inch in length. Twisted up on themselves like a spring in their egg-shaped cyst of lime, they lie dormant, yet ever ready, when set free, to cause as much suffering as any of the parasites that infest the human body. When infested flesh is eaten, the encysted trichinæ set free can be found in the small intestines. According to Gottheil they develop in one and a half days. They are now sexually mature, losing their spiral form and

reproduce in seven days. They increase very rapidly, each female bearing about 1,000 living young. The female is ⅛ inch in length, the male not so large, (See Figures 4 and 5.)

Figure 4.

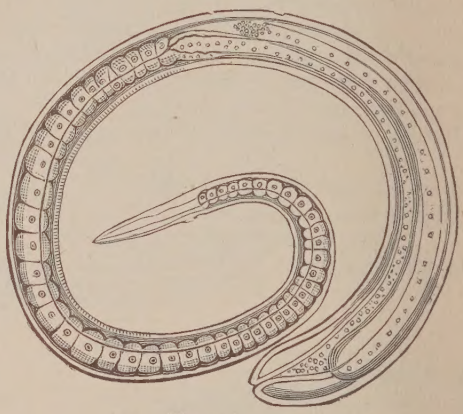

Figure 5.

MATURE FORMS OF TRICHINA SPIRALIS, HIGHLY MAGNIFIED.

Figure 4 is the adult male. Figure 5 the adult female. The small end in each case is the head. The female is about ⅛ inch in length, the male not quite so large.

As soon as the young are set free they penetrate into the muscular tissue of their host, sometimes burrowing into the muscles of the far extremities, but the greatest number can be found in the abdominal and thoracic muscles. After a time these small trichinæ become encysted. It is possible for adult trichina to be found in the alimentary tract of all animals in whose muscles they have been found encysted.

Trichiniasis, trichinosis, trichinitis, trichina, or trichinous disease is the name given to the disease caused by Trichina spiralis.

The encysted trichinæ were found in the dissecting room thirty years before the disease was diagnosed. Zenker was the first to discover the clinical nature of the disease, in 1860. He records the death of a patient who died of trichiniasis, whose case in life, from its symptoms, was said to be typhoid fever. The post-mortem examination showed larval trichinæ encysted in the patient's muscles, also mature trichinæ in the intestinal canal.

Epidemics have occurred in North Germany at different times from eating uncooked pork, and also in England, in New York State,

and elsewhere. They were so disastrous in Germany at one time that the government appointed a commissioner to examine pork, and forbade the shipping of American pork to that country. It was claimed that pork from the United States was especially liable to be infested with trichinæ, from the fact that hogs in this country were not fed in cleanly manner, in being allowed to eat offal from slaughter pens and other matter more or less liable to contain the worms.

The cause of this disease has already been shown to be the presence of trichinæ in the intestinal tract and in the muscles of the patient. The effects upon the system resemble those of muscular inflammation. The symptoms are at first similar to gastritis, loss of appetite, nausea, vomiting, and slight elevation of temperature. At this time the trichinæ are in the intestines. Swellings appear at different parts of the body. These are very painful on manipulation. Thirst is now a marked feature, also frequent perspirations, temperature more elevated, and pulse quickened. This is when the parasites are burrowing their way into the muscles to become encysted there. The patient may be very constipated or suffer from constant diarrhœa. In about four weeks the symptoms abate and the fever diminishes; this is the time of great weakness; dropsical effusions appear at different parts of the body, and pneumonia and other complications are liable to occur. Death may end the misery of the patient at any period of the disease. It must be stated, however, that only when present in such large numbers as many millions that the worms may produce dangerous results. But from the great rapidity of reproduction it is not very difficult to reach this number after the person is much infected.

Treatment: Active purgatives should be given to remove the mature worms from the digestive tract. Calomel given in large doses and repeated at intervals has been found to act better than any other drug. During the weak state the strength of the patient should be looked after, and some of the numerous beef-tea extracts would be serviceable.

But the greatest of all remedies is preventive treatment. Always cook meat thoroughly before eating. A temperature of 175°F. (and this temperature should be reached at the centre of the piece of meat cooked as well as the surface) destroys these parasites. Be careful not to let hogs have access to offal or to excrement of any kind, and above all, allow no dead rats to be thrown in the pig pen, for rats are great spreaders of diseases of this nature. The practice of feeding pigs on slaughter-house offal should be absolutely condemned.

Why is it not as wise to enforce strict sanitary regulations in regard to health of animals whose flesh is to be eaten, as to our own personal health?

IMP. BUR.
16 MAY. 1914
ENTOM.

March 26, 1894.

North Carolina

Agricultural Experiment Station,

Bulletin No. 100.

OUR COMMON INSECTS.

Publications will be sent to any address in North Carolina upon application.

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RALEIGH, N. C.

OUR COMMON INSECTS

The causes that led to the publication of a bulletin upon the above subject were several: *First*, in order that the people of the State should have the means of studying and understanding the numerous insects, both foes and friends, constantly noted on every side. It is evident that this can be done to better advantage if the structure, classification, and life-history are known in connection with a knowledge of a particular specimen when it is being studied. *Second*, to extend a spirit of investigation and study among the children of the State, both at their schools and at home. It is expected that this will be accomplished by creating an interest in the collection of insects, and their preservation for permanent interest and value. In this way, if the activity of the children is aroused it will undoubtedly extend to the parents, and to both will result a better knowledge of insects and methods designed to destroy them. Many simple remedies can be applied that would save many crops to their owners if only these remedies were known. To aid in the creation of interest in the study of insects, the preservation of beneficial species, and the destruction of noxious ones, it is probable that the Experiment Station will offer cash prizes for the most meritorious collections of insects collected and named according to the classification of the present bulletin. The offer will doubtless be made only to the public schools of the State and their pupils. *Third*, to increase our own knowledge of the insect fauna living in the borders of the State, and in this study, collections carefully made as above described and sent in from all parts of the State, will be invaluable. The flora of North Carolina has been studied widely and is among the richest and best known in the world. In fact, the name *Caroliniana* appears as a part of the specific name of plants more frequently than that of any other State. This is doubtless due to the researches of two of her citizens of world-wide reputation, Dr. L. D. von Schweinitz of Salem, and Dr. M. A. Curtis of Wilmington, and of Michaux, the elder and younger, and other European botanists, who did most of their collecting in North Carolina. The flora of the State embraces some 6,000 distinct species, due to the varied elevations within her borders, and the consequent diversification of climate. As there is such close connection and mutual dependence between plants and insects, it is doubtless the fact that there is relatively as large insect fauna within the State and as interesting as the flora. No such attempt has ever been made to systematically study our insect life. It is desirable that a beginning should be made, and collections from different portions of the State carefully made by the various schools would be of great assistance in the work. At the same time, collections made in this way would tend to increase the interest of school pupils in natural sciences, would teach them the value of observation of the life and events around them, and which, in addition, would be of marked value to them in after life as agriculturists. This interest would doubtless extend to their parents, who would in turn derive benefit from their labors.

With these three purposes and results in view, the present bulletin was written by the Entomologist of the Station, Mr. Gerald McCarthy. Its scope can be seen from the table of contents on the following page. Of the sixty-five cuts used to illustrate the text, the following very instructive ones were very kindly loaned by Dr. Otto Lugger, Entomologist of the Minnesota Experiment Station, and to whose courtesy we are greatly indebted: Nos. 1, 2, 9, 11, 23, 35, 36, 37, 38. 41, 41a, 51, 53, 54, 57, 58, 59, 60, 61, 62.

H. B. BATTLE, DIRECTOR.

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[The above Table of Contents presents a condensed Summary of the several subjects treated in this Bulletin. The detailed matter will be found in the following pages (185 to 216). Persons who do not receive these latter pages can be supplied by making application for the complete Bulletin to Dr. H. B. BATTLE, Director, Raleigh, N. C.]

OUR COMMON INSECTS.

By GERALD McCARTHY, Entomologist.

During the warmer months of the year, insects, including flies, beetles, bugs, butterflies, moths, etc., are everywhere among the most abundant of living creatures. Insects are always interesting on account of their colors, form and sounds, and frequently annoying by their attacks upon ourselves, our animals, and our crops. To farmers, gardeners and fruit-growers, the life-histories of many insects is a matter of no small interest. Many species of noxious insects are so common and destructive to crops as to inflict each season very serious damage; at times they may invade whole counties in such swarms as to sweep away in a few days every green plant, and threaten famine to the people of the invaded district. Not every species of insects is noxious. The useful honey-bee and silkworm moth have been domesticated for ages. Many other species are useful by carrying the pollen of one flower to the pistil of another flower, thus causing cross-fertilization and better crops. Still another class of insects benefit mankind indirectly by preying upon noxious species. It is desirable, then, that farmers and gardeners should learn to discriminate useful from noxious insects. During the last 25 years, the number of noxious species of insects has increased with the most alarming rapidity.

It is necessary now that everyone who cultivates or has charge of a farm, garden or fruit yard should be sufficiently acquainted with the life-histories of noxious species to be able to combat them intelligently, and at the period when they are most exposed to attacks. Owing to the great difference in the appearance and habits of insects at different stages of growth, different methods must be employed against the same species at different times.

The present bulletin is an attempt to bring together in a short space and a popular form the principal facts of classification and history of the orders and genera of insects most common with us, in the hope that it may lead our farmers, their sons and daughters, to pursue this study further with the aid of special text-books, some of which will be named at the end of this bulletin. Another object is to induce young people to make a collection of the insect fauna of the State, and thus increase their knowledge of the subject and arouse additional interest in its study. All insects collected and forwarded to this Station according to the instructions given in this bulletin

will be identified and named free of charge, and all possible aid will be given to those who desire to engage in the work.

The particular science which treats of insects is called Entomology. The word is of Greek derivation and means a discourse about insects. "Insect" is from two Latin words which mean something cut into parts or rings such as make up the bodies of insects. For convenience in study, men of science have arranged all natural objects under three principal and many subordinate divisions. The principal divisions are the mineral, vegetable, and animal kingdoms. It is easy to tell at a glance to which of these kingdoms any ordinary object belongs. Insects obviously belong to the animal kingdom. The annexed diagram shows their relationship to other animals, and to nature at large.

The classification of insects is not yet permanently fixed. Some authors arrange the whole subclass of insects under seven orders; others make as many as 16 or 20 orders. The seven-order arrangement is the oldest, is very simple and, for practical purposes, is as good as any. We shall adopt this classification in the following pages:

CLASSIFICATION OF INSECTS.

Kingdoms. — Nature: Minerals. Plants. Animals.

Series. — Animals: Vertebrates (with backbones). Invertebrates (without backbones).

Branches. — Invertebrates:
1. Protozoa (uni-cellular animals).
2. Porifera (sponges).
3. Cœlenterata (corals, jelly fishes).
4. Echinodermata (star fishes).
5. Vermes (worms).
6. Molluscoideæ (sea polyps, etc.).
7. Mollusca (oysters, clams, etc.).
8. Arthropoda.

Classes. — Branch 8. Arthropoda: Crustaceans (crabs, lobsters, etc.). Insects.

Subclasses. — Insects: Malacopoda (peripatus). Myriapoda (centipedes, etc.). Arachnida (spiders and mites). Hexapoda.

Orders. — Myriapoda:
I. Chilopoda (centipedes).
II. Pauropida.
III. Diplopoda (millipedes).

Orders. — Arachnida:
I. Arthrogastra (scorpions).
II. Araneina (spiders).
III. Acarina (mites).

Orders. — Hexapoda:
I. Hymenoptera (bees, wasps, etc.).
II. Coleoptera (beetles).
III. Lepidoptera (butterflies, etc.).
IV. Diptera (flies).
V. Hemiptera (bugs).
VI. Arthroptera (grasshoppers, etc.).
VII. Neuroptera (dragon flies, etc.).

The term "insect" is used in a somewhat different sense by different scientists. Some include under this name spiders, mites and centipedes—insected animals which have eight or more feet. Others restrict the name to six-footed insected animals. The best authorities, however, as well as nearly every intelligent non-scientific per-

son, consider mites, centipedes, spiders, etc., true insects. A special subclass *Hexapoda* (six-footed) is given for the six-footed insects, which, in addition to having just that number of legs, differ from spiders, mites and centipedes by the series of changes, or *metamorphosis*, through which they pass from the egg to the adult animal. Let us take the very common "cotton caterpillar" as an illustration of the changes through which most species of insects pass. First, there is the egg which the parent moth lays on the cotton plant. From this at the natural temperature of the air there hatches in two or three days a tiny caterpillar which looks more like an ordinary earth-worm than the winged parent moth. This caterpillar grows quite rapidly, casting off its skin like an old coat every four or five days. During this period it is, as farmers well know, a most voracious feeder, eating more than its own weight every 24 hours. At the end of about 20 days the caterpillar is full grown, stops feeding, and rolls itself up in a leaf of the cotton plant which it fastens together securely with silk threads. In this retreat it casts its skin for the last time and appears as a "chrysalis," which is a dark-brown, legless and seemingly lifeless object very different from the caterpillar. In the chrysalis state it remains dormant for about a week or ten days, and then bursts forth as a winged moth precisely like the parent moth. The sexes pair after a few hours and the female moth begins to deposit eggs, which pass through the same series of transformations. All our six-footed insects do not pass through the whole series of changes described above, there being various degrees of incomplete metamorphosis. The female of most species of insects lays from 50 to 3,000 or more eggs. The usual duration of the life of a winged insect is, in summer time, only a few days or weeks, though in cold weather a winged insect may live in a dormant or cold-benumbed condition through the winter, and wake up to lay eggs in the following spring. In the second or *worm-like* state, the "larva," the insect commonly lives for from a month to a year. A few species live two or three years, and the 17-year cicada lives in this form in the ground for from 13 to 17 years. It must always be borne in mind that though we shall frequently call insect larva "worms," we do so only out of deference to common usage. They are not true worms. Worms belong to the fifth branch of the invertebrate series. [See diagram, page 186]. The "pupa" state, in which the insect changes from a worm-like animal to a winged one, lasts, as a rule, but a few weeks, usually less. Before passing into the pupa state many insects construct protection cases. The pupa case is usually called the cocoon. In many species the cocoon is a very elaborate affair, as, for example, that of the silkworm, from which the raw silk of commerce is obtained. In other species the cocoon is quite rude, or wholly lacking. Although many species pass the pupal stage above ground, the majority burrow into the ground for this purpose. There they make a kind of cell and cement or line the sides with mucus or silk.

Insect Names and Organs.

The scientific name of insects always consists of two or three words—which are Latin or Greek. The first word is the generic name, which corresponds to the family name of humans; the second word is the specific name, similar to the given name of humans; a third word is sometimes used to express a varietal distinction—the generic name of insects differing from human names in that it always precedes the specific name. The names used in science are often difficult to pronounce and to remember and are to most people meaningless. Yet the use of common or vernacular names cannot be accepted in science, because one species often has several names in the same neighborhood, and in foreign countries each language has different common names for the same species. The Latin and Greek names are the same in all countries, and thus confusion is prevented by using them.

All six-footed insects breathe through tubes called *trachea*, which open along the sides of the worm-like "larva," and under the wings of the adult or "imago."

The bodies of all Hexapodous insects are divided into three well distinguished parts, and each separate limb and portion of a limb has a special name. Figure 1 shows a grasshopper dissected into distinct parts, to each of which its proper name is given. (See Fig. 1.)

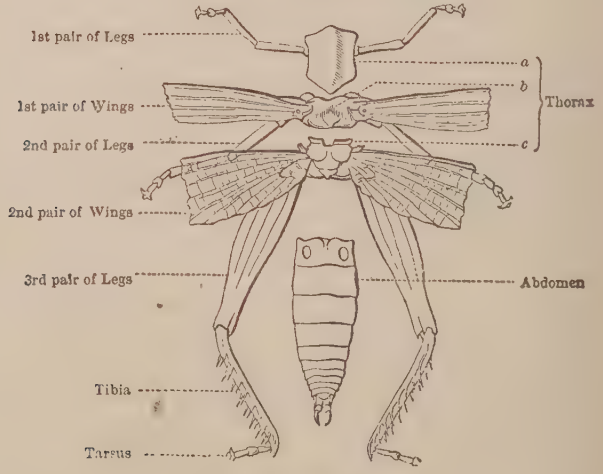

Fig. 1. A dissected insect.

The first joint or segment is the head. To this are attached the *antennæ*, or feelers, and eyes. The second joint has attached the first pair of legs; the third joint has attached the first pair of wings and

second pair of legs; the fourth joint has attached the second pair of wings and third pair of legs. The second, third and fourth joints are collectively called the chest or *thorax*. Although shown as separate parts in the figure, in case of most insects these three portions are so closely joined that it is difficult to distinguish the separate joints. The remaining joints form the *abdomen* of the insect. To this division are attached the sexual organs, but these are not shown in the figure. The leg of a Hexapodous insect is divided into five distinct parts, to each of which a separate name is given. The joint next to the body is called the *coxa*. The second joint of the leg is called the *trochanter*. In the figure the *coxa* and *trochanter* are hidden by the wings. The third joint is the *femur*, the thickest portion of leg; the fourth joint is the *tibia*, the fifth joint is the *tarsus*.

SUBCLASS—HEXAPODA OR HEXAPODS (SIX-FOOTED INSECTS).

Order I.—Hymenoptera, or Membrane Winged Insects.

This order includes the honey and bumble bees, wasps, hornets, red and black ants, ichneumon flies, saw flies, horn-tails, and a few other genera. The Hymenoptera have mouth parts fitted both for sucking and biting. They have four membrane-like wings, and the metamorphosis is complete. The tip of the abdomen in the female ends in a sting or lancet, which is also an egg tube or ovipositor. This is one of the smallest of the natural orders, and for intelligence and value to humanity stands at the head of the entire class of insects.

As is well known, bees and ants live in well organized communities with division of labor. The most useful and best known of insects is the honey-bee, *Apis mellifica*. The honey-bee is not only useful for its honey, but also because it helps to cross-fertilize the flowers of plants. This insect often pierces or tears the rind of fruits and then sucks their juices, and when nectar-giving flowers are scarce it undoubtedly often does considerable damage in this way; but its principal food is the nectar of flowers, and its benefits far outweigh its occasional depredations. In searching for nectar it carries the pollen of one flower to the pistil of another, thus causing cross-fertilization, without which our crops would soon deteriorate. Each hive contains one queen or mother-bee, and during the swarming period some one hundred or more male or drone bees. The rest of the bees, amounting to some thousands, are all neuters, or working bees. The queen, or, more properly, mother-bee, lays something like a million eggs during her life, which may last for three to five years. The drones are ruthlessly stung to death by the workers as soon as the last queen has emerged from the cells and left the hive. The drones usually live but a few weeks. The worker bees in summer time die a natural death at six or eight weeks of age—their places

being continually filled by those newly hatched. The queen or mother-bee lays her eggs in certain cells in the comb. The eggs hatch in a few days into small, footless, and very helpless grubs, which are tenderly cared for and fed by the workers until they have passed through the whole cycle of changes and become winged, when they take their places as workers. Queens are produced from eggs laid in extra large cells, in which the grub is fed with a special kind of food called "royal jelly." Male or drone bees are said to be produced from unfertilized eggs, but this is rather doubtful and contrary to general experience.

The bumble bee is far less intelligent than the honey-bee. It lives in small colonies in holes in the ground. There are also several species of bumble bees which live solitary lives.

Of wasps (genus *Polistes*) and hornets (genus *Vespa*) we have several genera which are social and live in small communities. There are also solitary genera. Wasps do not secrete wax like bees. They make nests or cells of a substance resembling paper, made by chewing bits of wood. Some make nests of mud, plastered against walls of buildings. Solitary wasps usually burrow in the ground. The winged insect feeds upon pollen and the nectar of flowers, but the larva or grub feeds upon other insects, which are provided by the mother. Wasps and hornets, in spite of their pugnacity, are very useful insects, as they destroy vast numbers of noxious insects in providing feed for their young. They never attack men or animals except in self-defence.

Ants (genus *Formica*) are among the most interesting and intelligent Hymenoptera. Most ants, as we see them, are wingless; but at certain periods the female and male ants possess wings, which they subsequently drop as useless. Ant-hills like bee-hives contain three forms of insects—males or drones, females or queens, and neuters or workers. Some of the neuters are of extra large size and seem to be the soldiers or police of the colony. A single ant-hill or burrow may contain over a million insects. Ants are very intelligent, and not only provision their nests for time of scarcity, but also domesticate other insects, such as aphides, which they care for much as men do for domestic animals. Some kinds of ants even enslave other species and compel these to do the work of the colony. Ants are chiefly vegetable eaters, but they eat flesh when they can get it, and in the cotton fields of the South they do good service by killing and devouring cotton and boll-worms. The common yellow ant, which lives in cracks of floors and closets in houses, is *Myrmica molesta*, and though often a great nuisance it does useful work as a scavenger.

The Ichneumon and Chalcid Flies (see Fig. 2), of which there are a great many genera and species, are probably the most useful of all predacious insects in repressing the undue expansion of noxious species. The female fly lays her eggs upon the bodies of caterpillars and grubs, and with certain species upon the eggs of other insects. When the parasitic eggs hatch, the young grubs eat their way into the body of their host, and feed upon it, eventually killing it. The

horn-tails are wood-boring larvæ and do a vast deal of damage to elms, maples and other shade trees. Our most destructive horn-tail is *Tremex columba;* its most potent enemy is the Ichneumon fly, *Thalessa lunator,* which has an ovipositor several inches long, by means of which it can reach the borer at the bottom of its burrow.

Fig. 2. Ichneumon Flies.

The Hymenoptera contain few noxious species, and as a whole are very beneficial to humanity.

Order II.—Coleoptera, or Sheath-Winged Insects.

Fig. 3. A Beetle.—*Dynastes tityus.*

This order includes all the sheathed or "hard winged" insects commonly called beetles. (See Fig. 3.) They have a mouth fitted for biting only; they have four wings, of which the front pair are thick and horny, the hind pair are membrane-like, and when the insect is at rest are folded beneath the front pair. The metamorphosis is complete. (See Fig. 4. Imago, larva and pupa.) The larva is called a grub when thick and fleshy, but when slender it is often called a wire-worm or simply "worm." This is considered the largest of the seven orders; the total number of species being estimated at above 200,000. In intelligence and usefulness this order is far inferior to the Hymenoptera. No species of beetles, so far as known are

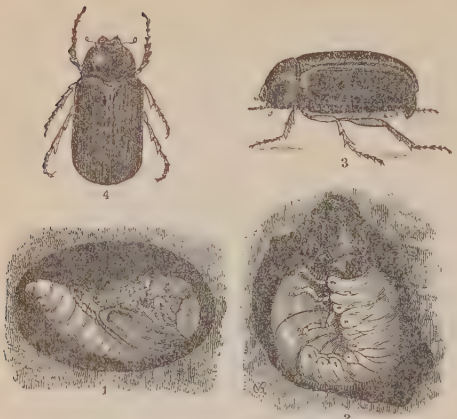

Fig. 4.
3 and 4, May Beetle; 2, larva; 1, pupa.

Fig. 5. Blister Beetle.

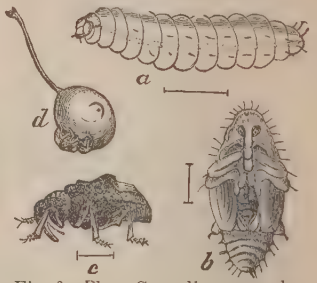

Fig. 6. Plum Curculio. *a*, grub; *b* and *c*, beetle; *d*, egg laying on plum.

Fig. 7. *b*, Pea Weevil; *a* and *c*, grub.

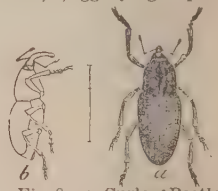

Fig. 8. *a*, Curlew Beetle; *b*, side view of beetle.

Fig. 9. Hazlenut Weevil.

social. A large number of our worst agricultural and household pests belong to this order. Among these may be named the Colorado and blister beetles (see Fig. 5) which damage growing Irish potatoes; the squash-borer, curculios (see Fig. 6); *weevils(see Fig. 7); bark-boring beetles (see Fig. 11); carpet beetles, etc., etc. The beneficial species are those which prey upon noxious species. Among these the place of honor belongs to the little beetles popularly called lady-bugs or lady-birds, and next to these we may place the tiger and ground beetles, of which illustrations are given.

*NOTE.—Where hair lines | —— | are placed near a cut these show exact size of object; where there is no hair line cut is natural size.

The lady-bugs are the natural enemies of plant lice. The larva of the lady-bug resembles a miniature alligator, and its appetite for plant lice is simply amazing. The lady-bugs vary in color and size,

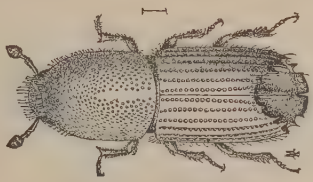

Fig. 10. Bark Beetle.

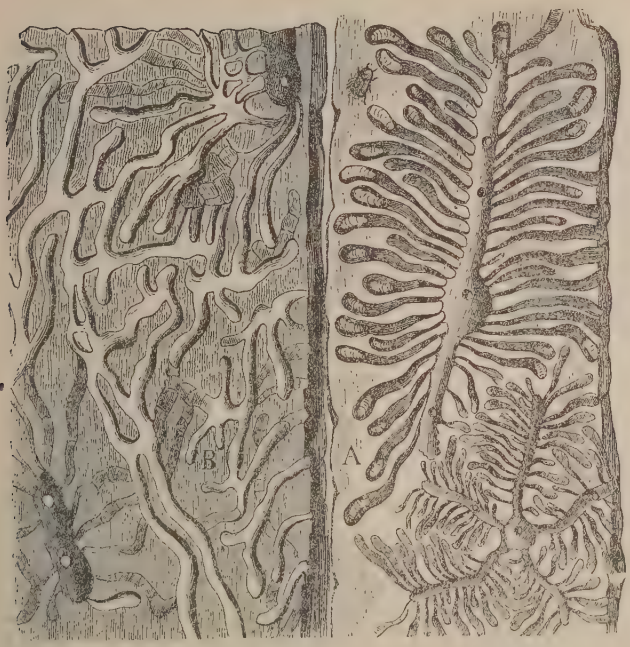

Fig. 11. Burrows of Bark Beetle.

Fig. 12. Corn and Strawberry root borer. *a*, grub; *b* and *c*, beetle.

but they are all small, and the usual colors are red, or pink spotted with black; black spotted with red, and yellow spotted with black.

The noxious cucumber beetle *Diabrotica vittata* may be known from the true lady-bug by its being *striped* instead of spotted. Lady-bugs with us are never striped.

The squash-borer, *Diabrotica* 12-*punctata* (Fig. 13), resembles a lady-bug, but it is larger and has long "feelers," which lady-bugs have not. The Diabrotica is greenish-yellow, with black spots.

There is another insect closely related to the true lady-bugs (*Coccinella* and *Hippodamia*), which feeds upon cucumber and squash plants. This is *Epilachne borealis*, shown at Fig. 14. It is of a reddish-yellow color, with seven black spots on each wing cover. It is much larger than the true lady-bug.

Fig. 13. Squash Borer.

Fig. 14. Epilachne Borealis.

Fig. 15. Spotted Lady-bug and larva.

Fig. 16. Convergent Lady-bug. *a*. Larva. *b*. Pupa. *c*. Adult.

Among our most common and useful allies are the following:

The 9-spotted Lady-bug, *Coccinella novempunctata*, Fig. 15. This beetle is brick-red, with nine black spots.

The Convergent Lady-bug, *Hippodamia convergens*, Fig. 16. This is orange-red, with thirteen small black spots.

Fig. 17. The Fiery Ground Beetle (*b*) and larva (*a*).

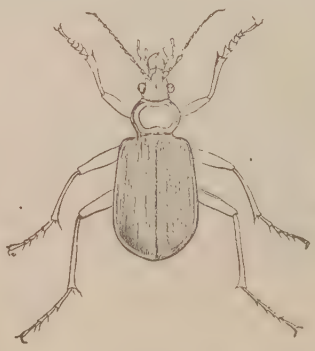

Fig. 18. Green Ground Beetle.

Fig. 19. The Murky Ground Beetle.

The Fiery Ground Beetle, *Calosoma callidum* (Fig. 17), is one of our largest, most beautiful, ferocious and rapacious insects. It feeds chiefly upon cut-worms, but destroys vast numbers of cotton and boll-worms. This beetle is shining greenish-black, with golden dots in straight rows. It is most useful in the larva state.

The Green Ground Beetle, *Calosoma scrutator* (Fig. 18), is one of our most common, elegant and useful insects. It is of a shining green color, without spots or stripes.

Figs. 19 and 20 show the Murky Ground Beetle, *Harpalus caliginosus*, and its larva. The beetle is of a blackish color, of the exact size shown.

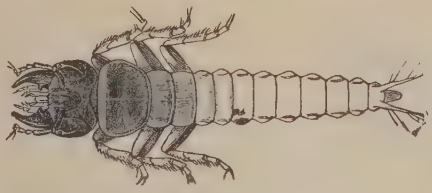

Fig. 20. Larva of Murky Ground Beetle.

Fig. 21.
Virginia Tiger Beetle.

Fig. 21 shows the Virginia Tiger Beetle (*Tetracha Virginica*). It is of a shining green color, with brown legs, of the exact size shown.

Fig. 22 shows the Elongated Ground-Beetle (*Pasimachus elongatus*). It is of a shining black color, with dark-blue edges.

Fig. 22.
Long Ground Beetle.

While the vast majority of beetles are dwellers on land, a few are aquatic and many of these are beneficial, feeding upon the larvæ of mosquitoes and other aquatic vermin.

Fig. 23. Predacious Water Beetles and larva.

Order III.—Lepidoptera, or Scale-Winged Insects.

This order includes the beautiful insects popularly called butterflies and moths. These have a sucking or lapping mouth in the winged state. The wings are always four and of the same texture, being covered with scales laid on as shingles on a roof. The metamorphosis is complete.

The two great divisions of this order—butterflies and moths—may be distinguished from each other by the following signs. When at

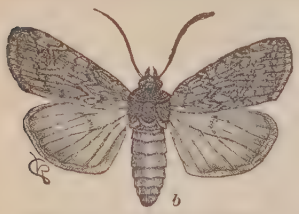

Fig. 24. A Cut-worm Moth.

Fig. 25.
Larva of Moth—a cut-worm.

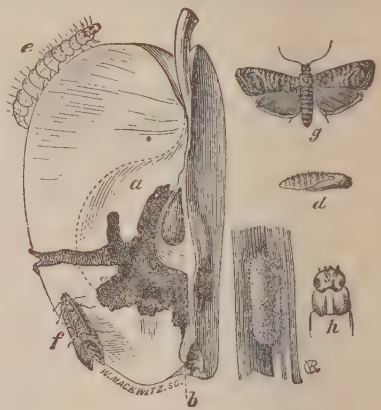

Fig. 26. Codling Moth. *a*, burrow; *b*, entrance hole; *d*, pupa; *e*, larva; *f*, moth.

Fig. 27. Canker Moths. *a*, male; *b*, female.

Fig. 28. Canker Worm (*f*), and eggs (*a*, *b*, *c*.)

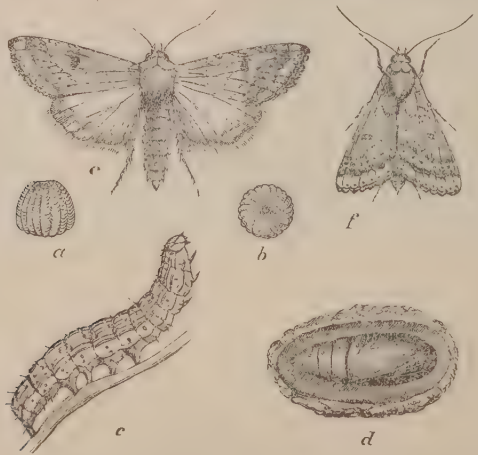

Fig. 29. Boll-worm. *a*, *b*, eggs; *c*, larva; *d*, pupa; *e* and *f*, moth.

rest butterflies hold their wings vertically, so that these are placed back to back, whereas moths at rest hold their wings flat on the body

or sloping downwards like the roof of a house. Butterflies are day flyers and love the bright sunlight; moths mostly fly at twilight. The larva of both moths and butterflies is called a caterpillar (see Figs. 24, 25 and 26). The pupa is called a *chrysalis*, (plural, *chrysa-*

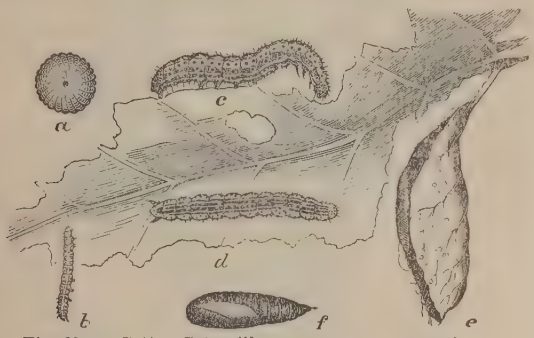

Fig. 30. *c*, Cotton Caterpillar. *a*, egg; *e*, cocoon; *f*, pupa.

lides). The metamorphosis is complete. This order is one of the largest of the seven. The species is most abundant and of largest size in the tropics. Although structurally the butterflies rank higher

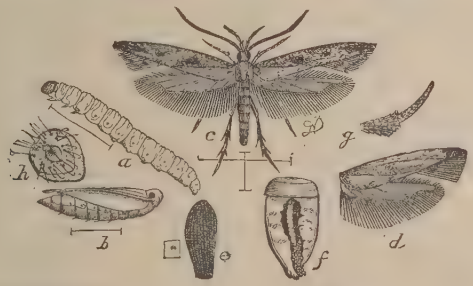

Fig. 31. Angoumois Grain Moth. *a*, larva; *b*, pupa; *c*, moth; *e*, egg; *f*, burrow.

than the moths, the latter division of the order is the most important from an economic standpoint—it includes the useful silkworms and some of our most destructive agricultural pests. Among the latter

Fig. 32. Peach Borer Moths. 1, female 2, male.

we may name the codling moth (Fig. 26), canker-worm moths (Figs. 27 and 28), boll-worm moth (Fig. 29), cotton worm (Fig. 30), tobacco moth Angoumois grain moth, (Fig. 31), peach borer moth, (Fig. 32) and cut-worm moths, of which there are several species.

Among the butterflies the most injurious genus is the white and yellow cabbage butterfly, *Pieris oleraceæ*. All Lepidoptera do their

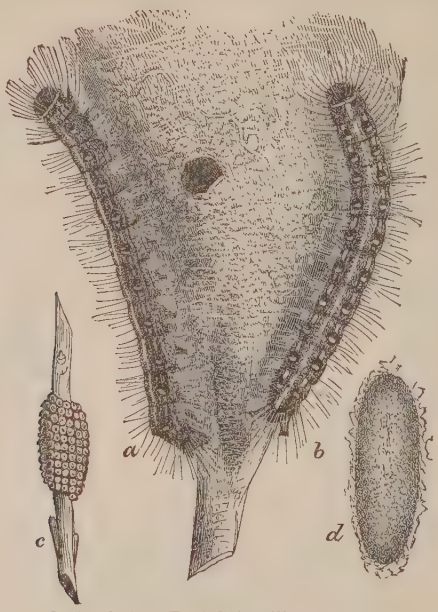

Fig. 33. *a*, *b*, Apple-tree Tent Caterpillars; *c*, eggs; *d*, cocoon.

damage in the larval stage. As winged insects they either do not feed at all or feed upon the nectar of flowers. Most caterpillars live

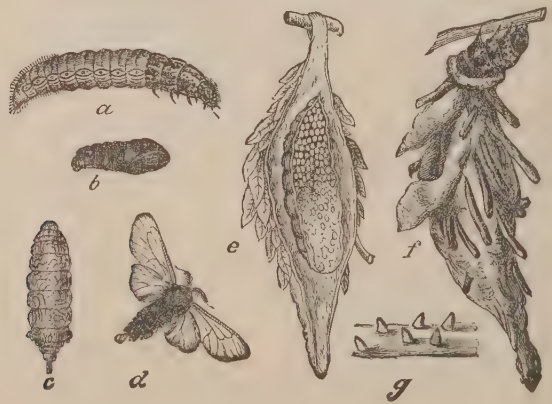

Fig. 34. *a*, Bag-worm of Pear Tree; *d*, moth; *e*, eggs; *f*, worm in bag.

without shelter of any kind—a few species construct nests or tents and some a sort of movable bag or case. (See Figs. 33, 34).

Order IV.—Diptera, or Two-Winged Insects.

This order includes the two-winged insects commonly called flies. The mouth parts of flies are fitted for piercing and sucking only. They do not chew or tear their food as do beetles, but most of the species have a very sharp lancet, by means of which they pierce the skin of men and animals and then suck the blood. The wings are always two, with a pair of little knobs on short stems behind the wings. The larva of flies is called a maggot. The metamorphosis is complete. (See Fig. 35—egg, larva, pupa and imago.) This is one of the largest of the seven orders, the number of species being very large. The intelligence of this order is not high, and many of the most degraded parasitic forms belong to it. In an economical sense it is very important, as it includes some of our most troublesome insect enemies. Of these we may name the house fly, mosquito, bot fly, warble fly, Hessian fly, horn fly, and many more.

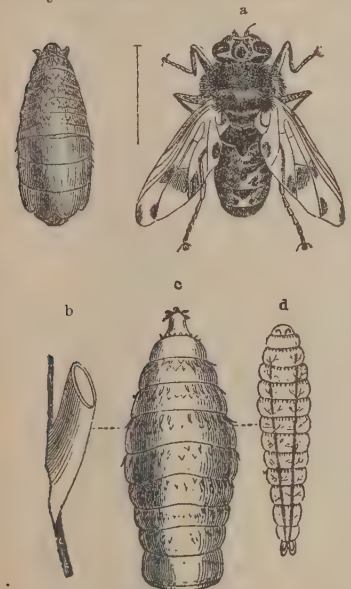

Fig. 35. Bot Fly of Horse. *a*, Fly; *b*, egg; *c* and *d*, larva; *e*, pupa.

The mosquito, *Culex pipiens* and *C. ciliatus*, is probably the most notorious of these pests (see Fig. 36). This insect deposits her eggs on the surface of stagnant or still water—usually in ponds, reservoirs and tanks. The larvæ are the well-known "wrigglers" or "wiggle-tails" seen in rain-water barrels which are allowed to stand exposed to the air. The female mosquito lays about three hundred eggs, and there are probably half a dozen generations in a year, hence the vast numbers of these pests in places favorable for their breeding. In justice to masculinity in general, it should be noted that the obnoxious mosquito and all blood-sucking flies generally are all *females*—the males usually live in retired places upon the nectars of flowers. It has been found that a very little

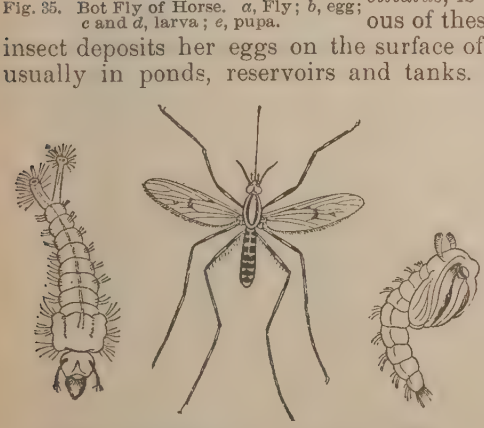

Fig. 36. Mosquito, larva, and pupa (magnified).

kerosene poured over the surface of ponds, tanks, etc., wherein mosquitoes breed will destroy the eggs and larva, thus freeing the vicinity of the undesirable presence of the adult female.

Fig. 37. Gad Fly.

Among the most troublesome flies are the Bot Fly of the horse, Gad and Warble Flies of the cow, and Nose Fly of the sheep (see Fig. 37). The Horse Bot Fly, *Gastrophilus equi*, lays her eggs on the hair of the front legs of the horse or on the sides or mane. These soon hatch, and the maggots cause an irritation of the skin, which makes the horse lick the spot, and thus the maggots are taken into the mouth, and eventually find their way into the stomach, where they attach themselves to the walls and feed upon the stomachic juices. Here they remain for about nine months. Eventually they let go their hold and pass out with the excrement, and find their way into the earth, where they transform to the pupal and winged stages. The Warble Fly, *Hypoderma bovis*, lays her eggs on parts of the body of the cow where the animal cannot reach them. The maggots bore beneath the skin, producing the sores and swellings familiar to most owners of cattle.

The Sheep Bot, or Nose Fly, *Œstrus ovis*, brings forth its young alive and deposits them in the nostrils of sheep while the animals are grazing. The maggots crawl up the nose passages to the frontal cavities, where they fix themselves, causing more or less discomfort and often death. Fresh tar on the nose of sheep will usually prevent the entrance of the grub.

The common house fly is *Musca domestica*. It lays its eggs, about seventy-five in number, on manure piles or decaying filth of any kind, upon which the maggots feed until ready to transform to the pupal and winged stages. The house fly does not bite or pierce. It is useful as a scavenger and is never found very abundant except where there is much decaying organic matter.

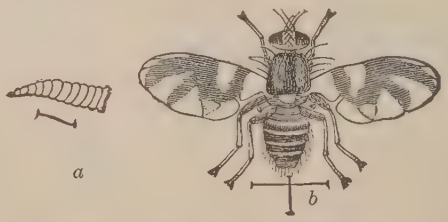

Fig. 38. Apple Fly (*b*) and Maggot (*a*).

Of outdoor agricultural pests, the worst in this order is probably the apple maggot, *Trypeta pomonella*, (see Fig. 38), and Hessian Fly (Fig. 39), *Cecidomya destructor*, a pest introduced from Europe with straw brought over by the Hessian mercenaries employed by the

English in the Revolutionary war. The Horn Fly, *Hæmatoba serrata* (Fig. 40), is a more recent importation from Europe, and is

Fig. 39. Hessian Fly; larva, pupa, and its parasite, *Semiotellus destructor*. *a*, egg; *b*, maggot; *c*, pupa case; *e*, *f*, female fly; *g*, male; *h*, position of maggot in wheat plant; *i*, parasite of Hessian fly.

now very annoying to cattle. The insects which produce the curious excrescences on oak trees, rose bushes, and many other plants, belong

to this order. The common gall-fly of the rose is *Rhodites rosæ* (Fig. 41). The Flea (Fig. 41a), *Pulex irritatans* and other species, also belong to this order.

Fig. 40. Horn Fly.

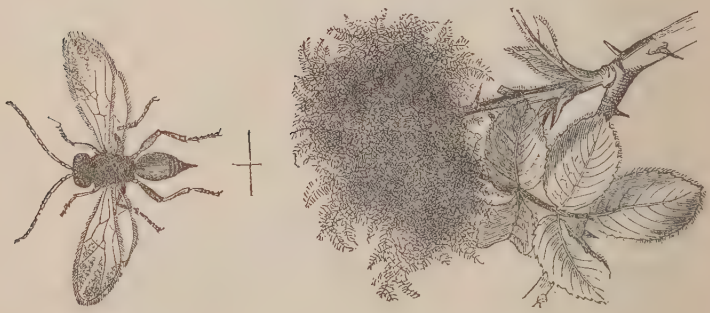

Fig. 41. Gall Fly and gall of the Rose.

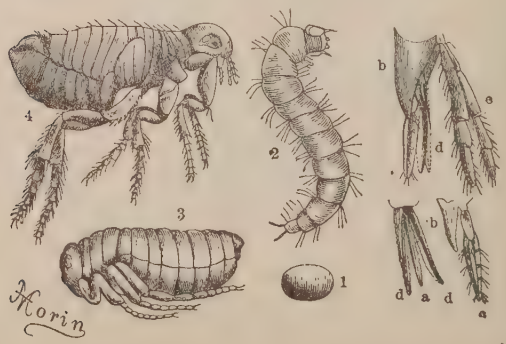

Fig. 41*a*. Flea (magnified). 1, egg; 2, larva; 3, pupa; 4. adult.

Order V.—Hemiptera, or Half-Winged Insects.

This order includes the periodical cicada and all the true bugs—chinch bug, squash bug, bed bug, and others having a similar unpleasant and characteristic odor. By some people all insects are called "bugs," but this is a misuse of words. The term "bug" should be restricted to half-winged insects, just as "beetle" is to the sheath wings. The mouth parts of true bugs are fitted for piercing and sucking only, being modified to form a sharp beak called the *rostrum*. The wings are four in number. The parts of the wings nearest the body are of a thick leathery texture, while the part towards the tips is membrane-like—hence the name half-wings. The Hemiptera are not a very large order, but include some of the most destructive of agricultural pests, as well as the most degraded

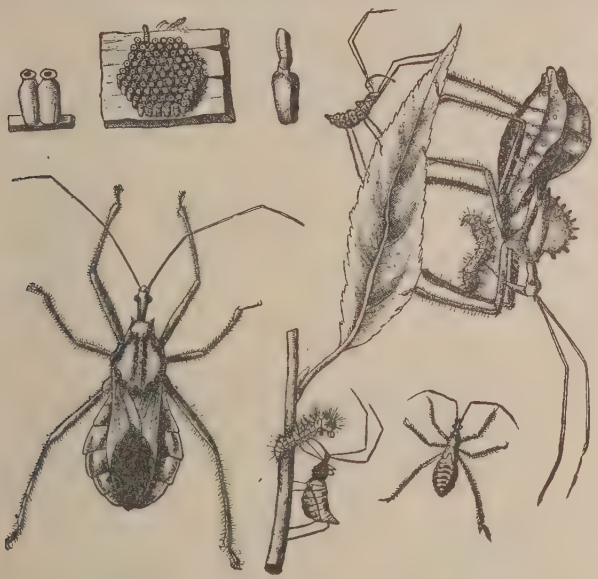

Fig. 42. Wheel Bug its larva and eggs.

and loathsome of known insects. The metamorphosis of bugs is incomplete. That is to say, the young do not pass through the cycle of changes, such as the beetles, flies, and bees do. The young bugs are hatched from eggs, but resemble the parents as soon as hatched, and do not make any sudden or considerable change in appearance while growing. They merely cast their old skins three or four times, and at each moult slightly change color and marking. They increase in size, but do not have wings until maturity. The young of bugs are called *nymphs*. A large number of species of this order are aquatic, and a few are predacious and benefit agriculture by destroying other insects. Among the useful bugs may be mentioned the

Wheel Bug, *Prionotus cristatus* (see Fig. 42); the Thick-thighed Soldier-bug, *Acanthocephalia femorata* (see Fig. 43), and the Banded Bug, *Milyas circinata* (Fig. 44). The Lac insects of the East Indies,

Fig. 43. Thick-thighed Soldier-bug.

Fig. 44. Banded Bug. *b*, beak magnified.

Fig. 45. Chinch Bug.

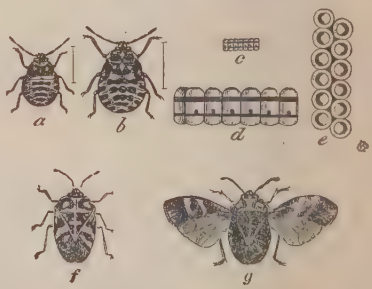

Fig. 46. Terrapin Bug, eggs and nymphs. *a*, nymph just hatched; *b*, same older; *c*, eggs; *d*, eggs magnified; *e*, section of egg cluster; *f*, *g*, adult bugs.

Fig. 47. Scale-bug of Apple.

Fig. 48. Apple aphides or lice.

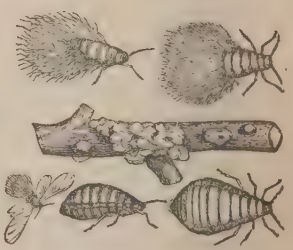

Fig. 49. Woolly Louse of apple.

Carteria lacca, and the Cochineal insect, *Coccus cacti*, of Mexico, are true bugs. So, also, are the scale insects of our orchards and plant lice generally.

Among the most degraded Hemiptera are the head and body lice of men and beasts. These insects by parasitic degradation have lost their wings. The head louse of man is *Pediculus capitis* (see Fig. 51); that of the body and clothing is *P. vestimenti*. Among our most

Fig. 50. Cabbage Louse. *a*, male; *b*, female—magnified.

Fig. 51. Louse of man (magnified). 1, head-louse; 2, body louse.

injurious pests may be named the following members of this order: bark, or scale bugs of apple, orange and other trees; Aphides, or plant lice proper; the chinch bug, squash bug, terrapin bug, and the grape phylloxera, which has caused such devastation in European vineyards.

Order VI.—Orthoptera, or Straight-winged Insects.

This order includes the grasshoppers, crickets, locusts, cockroaches, and a few other genera. These insects have a biting and

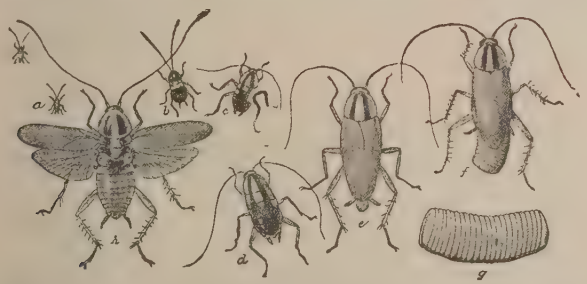

Fig. 52. Cockroach. *a*, *b*, *c*, *d*, *e*, cockroach at different ages; *h*, male insect; *f*, female; *g*, egg case.

gnawing mouth, and four wings which are parchment-like or membrane-like with straight veins. The metamorphosis is incomplete—the young resemble the parents and there is no quiescent or true pupal stage. The immature form in this order is called a nymph. This is the smallest of the seven orders, and is also the oldest, being the earliest insects whose remains are found preserved in the ancient sedimentary rocks of the earth. It is most abundant in dry regions. This order is for the most part noxious—the locusts and grasshoppers being terrible devastators in dry climates, and more or less troublesome everywhere. The cockroaches are well known and very

offensive pests of the household. One genus, *Mantis*, is exclusively carnivorous and feeds upon various noxious species, and is, therefore, useful (see Fig. 53). The most common species is *Mantis Carolina*, popularly called rear-horse, devil's riding horse, and praying mantis. It is very ferocious, and few insects can escape its grasp. The Walking Sticks, or Spectres, *Diapheromera femorata*, are closely related to the Mantis, but are exclusively vegetable eaters. In some

Fig. 53. Praying Mantis.

seasons they are very destructive to the foliage of oaks. These insects are protected from carnivorous insects and birds by their resemblance to the twigs of the trees upon which they feed. In spring and summer, when the leaves and young twigs are greenish, the insects are of the same color. As the color of the tree changes,

Fig. 54. Mole Cricket.

the color of this insect changes likewise. Most Orthoptera live above ground, but one genus—the mole cricket—is a burrower and lives under ground (see Fig. 54). There are several species of these, but our common mole cricket is *Gryllotalpa longipennis*. This insect eats earth-worms and the larva of other insects which come in its way

while burrowing, but its principal food is the roots of plants. The house cricket, *Gryllus domesticus*, is a European insect celebrated by poets for its connection with the domestic hearth. The snowy tree cricket, *Œcanthus niveus*, does much damage to blackberry and raspberry canes by depositing its eggs in them. The noisy katydid is represented by several species, of which the most common is *Cyrtophyllis perspicillatus*. These live upon trees and shrubs and are most active about twilight during June, July and August. The sounds are made by special organs on the wings and are supposed to be serenades to their mates. The Rocky Mountain Locust, which does so much damage in our far Western States, is *Caloptenus spretus*. The most common species in the Atlantic States is *Caloptenus atlantis*. The "Locust" of the Bible is probably *Pachytylus migratorius*, an Asiatic and African species which is not found in America.

Fig. 55. Eastern Grasshopper (*b*) and Nymph (*a*).

Order VII.—Neuroptera, or Nerve Winged Insects.

This order includes the dragon-fly, or "Snake Doctor" (see Fig. 56), the Dobson or hellgramite fly, the predacious and useful lace-wing fly (see Fig. 55), May fly, book lice, white ants or *Termites*, and others. By some authors this order is divided into three orders, called respectively *Neuroptera*, *Pseudo-neuroptera* and *Thysanura*. The mouth parts are fitted for biting and gnawing. These have four wings, except in the degraded species, which have lost their wings. The metamorphosis is incomplete. This is one of the smallest of the seven orders, and is of the least importance from an economical standpoint. The most destructive of this order of insects are the "white ants," *Termes flavipes*, *T. arborum*, and other species. These are not true ants, which belong to the Hymenoptera, the highest order of insects, as these to the lowest order. The white ants are wood-boring

Fig. 55. Lace-wing Fly, Eggs and Larva.

Fig. 56. Dragon Fly.

insects and often bore into and destroy the timbers of houses, furniture and anything made of wood. They are most abundant and troublesome in the tropics. Our species is *T. flavipes*, which is more commonly found in decaying pine stumps than in houses.

The common Dragon Fly, *Libellula tri-maculata*, is a very useful insect, as it feeds almost wholly upon mosquitoes and their larvæ. It is entirely harmless to men and the larger animals and should never be injured or persecuted. The May fly, of which there are several genera, the most common being *Ephemera* and *Palingenia*, are delicate aquatic insects which in the perfect or winged state live but a few hours. But as larva these live from one to three years. These insects furnish food for fishes and are otherwise quite harmless.

SUBCLASS ARACHNIDA.

This subclass includes spiders, scorpions, harvestmen and mites. These insects are distinguished from Hexapods by having eight legs instead of six. The head and trunk are also united in one piece called the *cephalo-thorax*. Antennæ or "feelers" are absent. All this subclass of insects have simple eyes. There is no metamorphosis. The scorpions bring forth their young alive. The total number of species included in this subclass is between 5,000 and 6,000, divided into three natural orders.

Order I.—Arthrogastra, or Scorpions.

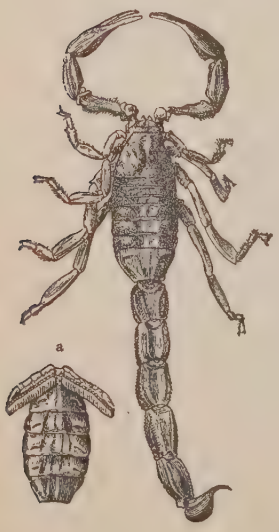

Fig. 57. Scorpions.

The scorpions (see Fig. 57) are the highest representatives of this order. These are found most abundantly in tropical countries. The total number of species is probably three hundred to four hundred. In North America we have sixteen or eighteen distinct species of scorpions.

Scorpions have a jointed body broad and flat in front, but narrow and tapering to a tail-like appendage behind. The last joint is armed with a sting and poison glands. They are all most venomous creatures, and so far as known have no positive economic value.

The harvest-men, or "daddy long-legs" are closely related to the scorpions. These, too, are most abundant in the tropics. In North America we have fifteen or twenty species. All our species are small and all are carnivorous, feeding upon smaller insects and are useful and harmless to mankind.

Order II.—Araneina, or Spiders.

All the spiders have eight legs, eight eyes, a biting mouth and the body divided into two parts. At the end of the abdomen are three pairs of spinnerets which produce the threads which form the web. (See Fig. 58.) There is no metamorphosis. The female is always larger than the male. The female usually lays her eggs at night and covers them with a silken case or cocoon. Some species carry this cocoon around with them until the eggs hatch, which they do in a few days. The young spiders eat their way out of the cocoon. Often they eat one another, so that out of a brood of a dozen only one or two live to escape from the cocoon. Spiders live in webs in houses, in holes in the ground, and a few species live under water in air-tight nests constructed like diving-bells. All are carnivorous and live upon insects—more especially flies. They do not sting, but bite and inject poison into the wound. The webs of spiders are made of silk threads far finer and more lustrous than those of the silkworm, but it has been found impracticable to use it. The most common genera in North America are *Attis*, *Tarantula*, *Epeira*, *Nephila*, *Theridion*, *Atypus* and *Erigone*. Tropical countries have the giant and venomous genus, *Mycale*, which kills and eats birds. Altogether we have about 800 species of spiders.

Fig. 58. Diadem Spider. 1, female; 2, male.

Order III.—Acarina, or Mites.

This order contains the mites and ticks. These have obscurely jointed bodies, eight legs, and a sucking and piercing mouth. Most species of this order are parasitic and more or less degraded in structure. The mite most troublesome to plant growers is the so-called "Red Spider," *Tetranychus telarius* (Fig. 59).

The disease called itch in men is caused by a species of mite (see Fig. 60), *Sarcoptes scabei*. *S. canis* produces the mange of dogs, and other animals have their characteristic species. Bats, birds and

poultry are very subject to parasitic mites. A few species are parasitic on fishes. "Texas fever" and "anthrax" in cattle are diseases transmitted and disseminated by ticks—species of *Ixodes*. These ticks cause an annual loss of several millions of dollars to the people of the Southern States.

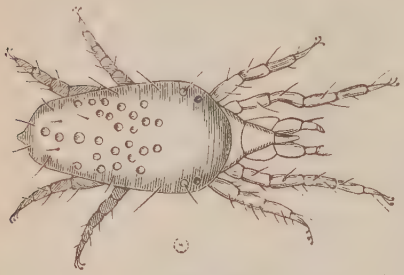

Fig. 59. "Red Spider" Mite—magnified.

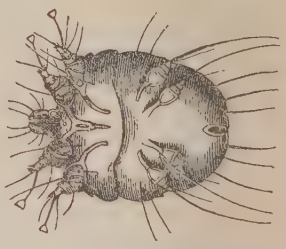

Fig. 60. Itch Mite, Female—highly magnified.

SUBCLASS MYRIAPODA.

This subclass includes all insects having more than eight legs, except the single genus, *Peripatus*. Centipedes, millipedes, etc., belong here. All the insects of this subclass are plainly jointed, have distinct heads with antennæ and jaws for biting, and in some species also for sucking. Most species are carnivorous and feed upon small insects; some eat rotten wood, and very few do harm. There is no metamorphosis. The subclass is divided into three natural orders.

Order I.—Chilopoda, or Centipedes.

Centipedes are flesh eaters and very active (see Fig. 61). Some species are venomous. All have one pair of legs for each joint of

Fig. 61. Centipede—one-half size.

the body. They are largest and most abundant in the tropics. *Scolopendra gigantea* and *S. morsitans* are the celebrated poisonous centipedes of the Indies and South America. The largest species in the United States is *Scolopendra castaniceps*, more or less common in

the Gulf States. *Cermatia forceps*, a smaller and non-poisonous species, is common in the Carolinas.

Order II.—Pauropida.

This is an obscure order of very small semi-aquatic centipedes, of which only a few species are found in the United States. It has no economic interest.

Order III.—Diplopoda, or Millipedes.

The millipedes have two pairs of legs on all except the first three joints of the body (see Fig. 62). The body is cylindrical and more or less hairy. The mouth parts are fitted for sucking and biting.

Fig. 62. Millipede—magnified.

The eyes are simple or absent. This order is not venomous. Our most common species of millipedes belong to the genus *Iulus*, often called galley-worms. These feed chiefly upon rotten wood and such dead insects as come in their way. These are sometimes found on scabby potatoes, but are not the cause of the scab. They are of little or no economic interest.

SUBCLASS MALACOPODA.

This subclass includes but a single and very singular genus, *Peripatus*, found only at the Cape of Good Hope in Africa, and New Zealand. These insects resemble millipedes and true worms. They are supposed to be the last surviving form of the ancestral type of all our modern insects. They have no other interest.

HOW TO COMBAT NOXIOUS INSECTS.

The scientific classification of insects has been given in the preceding pages. For economic purposes a different classification is to be preferred. Insects may be classified as beneficial, harmless and noxious. We have to deal here only with the third class. This may be further subdivided into (1) biting and gnawing insects; (2) sucking and piercing insects. Different methods of destroying these insects must be employed for the two classes. Insects which bite or gnaw the foliage of plants may be poisoned by any form of arsenic, which substance experience has shown to be the most practicable poison. Paris green, London purple and white arsenic are all useful for this purpose. For piercing and sucking insects, we must use a substance which will kill by contact. Kerosene oil, crude carbolic acid and sulphur have been found the best remedies for this class of insects. Weevils and burrowing insects cannot as a rule be reached by solid or liquid poisons, and against such we must use gases. The most useful poison for this purpose is produced by volatilization of bisulphide of carbon and cyanide of potassium. Sulphur fumes are especially valuable against ticks and mites. Air-slaked lime, soot, or fine powder of any kind, is often successful in killing insects—especially fat, sluggish grubs. These act by clogging up the breathing holes of the insects and smothering them. Persian Insect Powder, made from the flowers of species of *Pyrethrum*, a plant of the Aster family, is sold by most druggists, but is very unreliable for outdoor use. It stupefies the insects for a time and they fall to the ground as if dead, but nearly all recover after a brief period. A few insects seem proof against all practicable poisons, and these must be hand-picked when

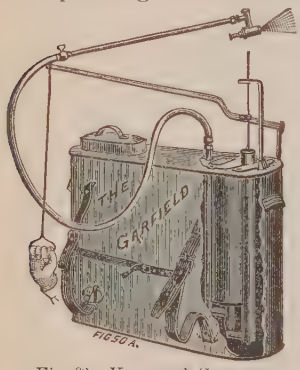

Fig. 63. Knapsack Sprayer.

Fig. 64. Barrel Sprayer.

Fig. 65. Powder Bellows.

they are too abundant. A fuller discussion of remedies suitable for different species of noxious insects will be found in various bulletins (Nos. 78, 84, 92, etc.), of this Experiment Station, to which the reader is referred for further information. These bulletins are sent free to all residents of the State who write for them. Figures 63, 64, and 65 show various forms of sprayers and blowers for combating insects in the field and garden.

HOW TO COLLECT AND PRESERVE INSECTS.

The apparatus needed for a young student of insects in field work is neither elaborate nor costly. The things necessary to take with one for a collecting excursion are as follows: A net or bag, which may be of mosquito netting sewed to a wire hoop, about twelve inches in diameter, attached to an old broom handle or stick. If the net is to be used a good deal it will be best to sew the top to a border of muslin two or three inches wide and attach the muslin to the wire. An old umbrella free from holes is an excellent thing for collecting weevils and such other tree-infesting insects as drop to the ground when disturbed. This will be all the better if the inside is lined with white muslin and the handle is hinged in the middle. A similar but stouter and shallower bag, with a handle not over three feet, is called a "beating net," and is much used to scare up and catch beetles and large insects which infest trees and shrubs. Still another and shallower net made of brass wire is used to collect aquatic insects. A twelve-ounce, wide-mouthed bottle containing a piece of cyanide of potassium the size of a hazel-nut covered with about one inch of wetted plaster Paris is necessary to kill insects, and this will usually suffice to hold all the captures of one day until one returns home. But some insects die hard in the cyanide bottle, and if they are put into a bottle containing butterflies or moths, their struggles are likely to cause the loss of the wing scales of the former. Therefore it will be well to carry a tight box small enough to go into the pocket or knapsack and some pins. This box may be lined on the bottom with thick pasteboard, and upon this the more delicate insects should be pinned as soon as dead. For very small specimens many collectors use pill boxes. Most insects should be pinned through the middle division of the body—the chest or thorax. Beetles, however, are usually pinned through the right wing cover and bugs through the triangular shield (*scutellum*) on the chest or thorax. Ordinary pins will do, but most entomologists use specially made pins. These are longer and more slender than ordinary pins. There are several

makes on the market, but those made by Klager, of Berlin, are most esteemed. They do not cost much and are sold by all dealers in scientific instruments. There are five sizes—No. 1 being the smallest, and No. 5 the largest. Usually Nos. 3 and 4 will give best satisfaction. Very small insects are mounted on triangular bits of cardboard and the pin put through the base of the triangle. Gum tragacanth is much used for attaching the insects. Ox-gall is often used for this purpose and for attaching legs and limbs which have been accidentally broken off. Before mounting in cabinet all insects should be soaked for a few days in a preservative liquid—fifty per cent. alcohol saturated with white arsenic is the best preservative. Common whisky may be substituted for the alcohol. Large caterpillars must be soaked for at least two weeks. The nests, galls and cocoons of insects should be soaked for ten minutes in the preservative liquid. After removing from the liquid, let them dry thoroughly, which will render them hard and brittle. Then place in a light box lined with moist blotting paper and let them lie until they become soft and pliable. Have ready a "setting-board." This may be a piece of one and a half-inch pine board with a rabbet or groove one inch deep and half-inch wide through the center—the long way. The face of the board should slant downwards towards the groove one-fourth inch or so. Have ready at hand a supply of pins—ordinary pins will do—and a lot of slender, triangular pieces of cardboard one inch long. Take a pliable insect from the damp box, spread out the wings and legs carefully and place it in the groove supported by the wings. Arrange the wings at their fullest extension and place over them one or more of the cardboard triangles and pin it tight enough to hold the wings in the assigned position. Let stand thus until the insect is dry, then remove and mount in cabinet. It should be remembered, however, that beetles are usually mounted with the wings closed, and for these the setting-board is not necessary.

As for the cabinet, instrument dealers sell many styles at almost any price. A common way is to have shallow drawers made in a frame like those used for holding spools of thread in dry goods stores. Each drawer is closed air-tight with a pane of glass sliding in a groove from the back. The bottom of the drawer is covered with cork or layers of pasteboard one-fourth inch thick and this again with white paper. The insect is pierced with the pin, and below it is a small label containing name, place and date of capture. Sometimes the label contains only a number referring to the collector's private catalogue, which gives all necessary information.

In spite of the arsenical preservative fluid, the cabinet will in time become infested with pests which will soon ruin the collection if left undisturbed. It will be well then every six or eight weeks to open the box and pour into each one, one-fourth teaspoonful of carbon bisulphide. Close tightly as possible and put away until the next application is needed. Keep the carbon bisulphide away from the light and fire, as it is very explosive. It is not poisonous unless

breathed for a long time. Caterpillars and grubs may be mounted the same as winged insects, but these are often preserved permanently in the arsenical solution referred to. Each larva should have a small homeopathic pill vial to itself. The label for this should be written in pencil and placed within the bottle. Another label may be gummed to the outside. A good and complete exhibit of any insect requires the three stages—larva, pupa and imago, or at least the larva and imago or winged stages to be shown. Also both sexes. Usually for the smaller kinds of insects both sexes may be mounted on the same pin, but butterflies and large insects are always mounted separately and the sexes indicated by the marks ♂ (Mercury) for the male and ♀ (Venus) for the female. Occasionally it will happen that only one stage of the insect can be found. In this case one should collect several specimens of that stage and put some of these alive into small bottles or boxes. These should be carefully handled, the food plant upon which it was found noted. When home is reached place some of the food plant in a large wide-mouthed jar or tumbler which has a few inches of soil in bottom. Place the larva or imago in this, and cover the mouth of the jar with gauze. Keep a plentiful supply of the food plant if you have a larva and watch it until it completes its metamorphosis. Several specimens should be secured, so that some may be removed for mounting to show intermediate stages of growth.

A careful record should be kept giving date and place of capture, food plants and any other information. This information should be included in owner's private catalogue.

BOOKS FOR STUDENTS OF ENTOMOLOGY.

Introduction to Entomology, by J. H. Comstock.
Guide to Study of Insects, by A. S. Packard.
Guide to Teaching Entomology. Hyatt and Arms.
Classification of Coleoptera of North America. Leconte & Horn.
Classification of Hymenoptera of North America. E. T. Cresson.
Classification of Lepidoptera of North America. J. G. Morris.
Classification of Lepidoptera of North America. J. B. Smith.
Butterflies, by S. H. Scudder.
Butterflies of Eastern United States, by G. H. French.
Diptera of North America. Osten Sacken.
Orthoptera of North America. S. H. Scudder.
Neuroptera of North America. Hermann Hagen.
Myriapoda of North America, by Horatio C. Wood.
Myriapoda of North America, by L. M. Underwood.
Spiders of the United States, by N. M. Hentz.

The following are valuable economic works:
Insects Injurious to Fruits, by Wm. Saunders.
Insects Injurious to Vegetation, by T. W. Harris.
Reports of the U. S. Agricultural Department, Washington.
Reports of the State Entomologist of New York.
Reports of the State Entomologist of Illinois.
Reports of the State Entomologist of Missouri.
Bulletins of State Agricultural Experiment Stations.

The above books can be ordered through any bookseller, or of B. Westermann & Co., or E. Steiger & Co., of New York. The reports are not usually sold, but can be had gratis on application to the secretaries of the different States and directors of Experiment Stations.